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AUBURN UNIV AL DEPT OF MECHANICAL ENGINEERING B A CHIN
1988 AFOSR-TR-88-0532 AFOSR-86-0233

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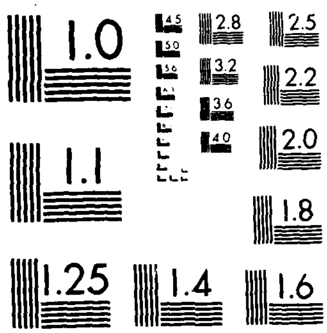


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SECURITY CLASSIFICATION OF THIS PAGE

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The equipment purchased und this grant is now in place and operational. This acquistion has alread enhanced our research capabiliteies in the are of structure identification enormously.



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FINAL REPORT FOR

GRANT: AFOSR-86-0233

TITLE: CRYSTAL STRUCTURES OF ORDERED CARBON METAL ALLOYS

PRINCIPAL INVESTIGATOR: BRYAN A. CHIN

This scientific instrumentation grant was awarded to Auburn University for the examination of crystal structures of the various ordered carbon metal alloy systems. The major instrument purchased was a high temperature x-ray diffractometer for in-situ phase identifications. The total award was $236,298 of which $189,000 was provided by the AFOSR and $47,298 was from Auburn University.

## Equipment Purchased Under This Grant

The following instruments were purchased under this grant.

| Item | Description | Cost |
|---|---|---|
| 1 | Rigaku/USA Inc. D/Max-IIITBX Theta-Theta X-ray Powder Diffractometer, for Control and Measurement with the following major options. | $197,265 |
| | High temperature attachment capable of attaining 2500 C in vacuum, to used on the theta/theta system | |
| | Theta/theta wide angle goniometer with coupled motion | |
| | Horizontal theta/2theta wide angle goniometer with dual axis driver for independent or coupled drive | |
| | MicroVax II computer control and data acquisition system | |
| | Complete software for the Rigaku system<br>Color monitor and plotter for the computer system | |
| | One copper fine focus and one copper normal focus x-ray tube | |
| | High resolution intrinsic silicon solid state detector and the associated power supply | |
| | Two scintillation detectors | |
| | Diffracted beam monochromator | |

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| 2 | High precision ion mill, for sample preparation, Gatan | $ 31,980 |
| 3 | High precision dimple system for sample preparation, Gatan | $ 7,200 |
| | Total: | $236,445 |

This final amount exceeded the total award by $147. This amount was paid by Auburn University's indirect costs return expenses (ICRE).

Item 1, the Rigaku system, is the main item purchased under this grant. This system includes all the necessary components to conduct diffraction studies at both ambient and high temperatures. It consists of two separate goniometers, one dedicated for room temperature use and one for high temperature. A high temperature furnace is included for the latter unit. Both units are controlled by a Digital Equipment MicroVax-II computer. This computer is fully equipped to perform data analysis and data plotting. To attain high resolution for peak separation, a state-of-the-art solid state detector was included. This silicon solid state detector has an energy resolution of less than 180eV and provides better signal to noise ratio and better resolution than the conventional scintillation detector. This unit is mounted on the high temperature goniometer, but is also compatible with the room temperature unit. The temperature function on the high temperature unit can be controlled either by its own control unit or by the MicroVax computer.

In the original proposed budget, $20,418 was allocated for a vacuum system (items 4, 5 and 6 in the proposal). However, a surplus vacuum system which exactly matched our requirement, became available. Therefore the funds were used to purchase an ion mill and a dimpler unit for special sample preparation purposes. These units were deemed necessary to prepare the high temperature alloys of interest to the Air Force projects.

## Selection Procedure

In the original proposal, the Philips diffractometer unit was suggested. During the course of the acquisition procedure, four separate sources were examined: Philips, Rigaku, Sintar and American Instruments. After an analysis of competitive sealed bids submitted by representatives of these companies, it was apparent that the Rigaku unit offers the best instrument for the price. Furthermore, it was the only unit on the market that had demonstrated software capabilities on a MicroVax-II computer. Therefore the Rigaku system was selected for this project.

## On-Going Research Projects Involving the Instrument

The followings are research projects that have benefited from the acquisition of the above described instruments. All three items purchased are used extensively on a routine basis. First priorities are given to DoD related projects.

1. High temperature carbon-metal alloys: This project is directly funded by the AFOSR and is progressing very well. C-metal systems being investigated include C-Ti, C-Zr, C-Mo and other ternary alloys based on these three systems. It has been determined that this new class of metal-ceramic hybrid materials possesses very high strength and relatively high ductility even at 1000°C. Furthermore, these materials are very light. These hybrid components are expected to have a significant impact on future aerospace applications. The x-ray unit is used extensively for phase identifications. At the present time, most of the studies have been conducted at room temperature to obtain a base-line for data analysis. Experiments are now underway to use the high temperature stage to determine the structure change as a function of temperature.

2. Dielectric composites for electrical applications: This project is supported by the DoD through the Army Missile Command at Huntsville, Alabama. We are interested in casting large components with tailored dielectric properties and good mechanical stability. These components will be used in switching circuits of spacecraft power systems. The materials which are being investigated are epoxy matrix-ceramic filled composites. One problem with the fabrication of these filled composites is the sedimentation of the filler during processing. The x-ray diffractometer is being used to determine this sedimentation by examining the peak heights from the filler at constant area. This method is statistically more superior than conventional microstructural analyses. Particle size will also be analyzed on this diffractometer unit.

3. High temperature superalloys: This project is presently supported by NASA to study the crystal structure of Ni-based superalloy single crystals for aerospace applications. The gamma and gamma prime structures in these alloys have very small orientation and lattice parameter mismatches. However, these mismatches are believed to be responsible for property degradation (especially hydrogen embrittlement). Work is now underway to precisely determine these mismatches using the high angle peaks from the diffractometer. It is anticipated that resolution better than 0.2% is possible.

4. Amorphous alloys: Work is underway at Auburn University to study the rapid pressure solidification as a means to produce alloys with better mechanical and corrosion properties. This work is supported by the National Science Foundation. However, amorphous alloys are also of interest to DoD because of their superior properties. Alloys based on aluminum were used. The newly acquired diffractometers were used to examine the structure modifications as a result of the rapid solidification. It was determined that the rapidly solidified alloys are still crystalline in nature but with small shifts in lattice parameter compared to their normally solidified counterparts. Such changes are attributed to the supersaturation state of the alloys due to rapid solidification.

5. Metal-matrix composites: Investigation is in progress to develop novel route of fabrication of short-fiber reinforced metal-matrix composites using powder metallurgy techniques. This work is supported by the National Science Foundation to provide research opportunities to both undergraduate and graduate students. The newly acquired x-ray system is used to determine the degree of separation of the fibers from the metallic matrix due to non-uniform mixing. This inhomongeneity is a direct result of the effect of gravity.

6. High temperature composites for aerospace applications: Several projects are now underway to study the structures of high temperature materials. These include carbon-carbon (C-C) composites and high temperature coatings. These materials undergo numerous phase transformations at elevated temperatures. These transformations results in cyclic stresses in the materials which can cause prematural failure. The high temperature diffractometer is used to identify these transformations in real-time instead of quenching. Residual stresses due to the differential cooling of the composites will also be examined.

7. Residual stress developed during welding of irradiated materials: Helium produced during the exposure of structural materials to an irradiation environment leads to a pronounced degradation of the weldability of the material. This is caused by the migration of helium due to the particular stress and temperature conditions developed during the welding process. The x-ray diffractometer is being used to map residual stress in welded specimens.

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